Swidden agriculture in transition and its roles in tropical forest loss and plantations expansion

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Abstract

Tropical forest and swidden agriculture are declining, while commercial plantation is continuously expanding. However, little is known about the mechanisms, processes and trends of the tropical forest-swidden-plantation (FSP) nexus. Global ongoing initiatives including the UN-REDD Programme, not only have repeatedly emphasized the significance of conserving forests, reforestation and afforestation, but re-pushed swidden agriculture to the forefront of a long-standing international debate of climate changes and biodiversity. Many facets limit our understanding of swidden agriculture. The lack of geographic and demographic data and their dynamics across the tropics undoubtedly further aggravate this situation since the first appeal of eradication of shifting cultivation by the FAO. Although recent studies have enriched significantly our knowledge of forest loss and plantation expansion, previous research has proceeded separately and has yet to be integrated under the umbrella of sustainable swidden agriculture. Efforts are needed to investigate the dynamics of the FSP nexus for sake of a synergetic goal of climate mitigation and poverty alleviation.

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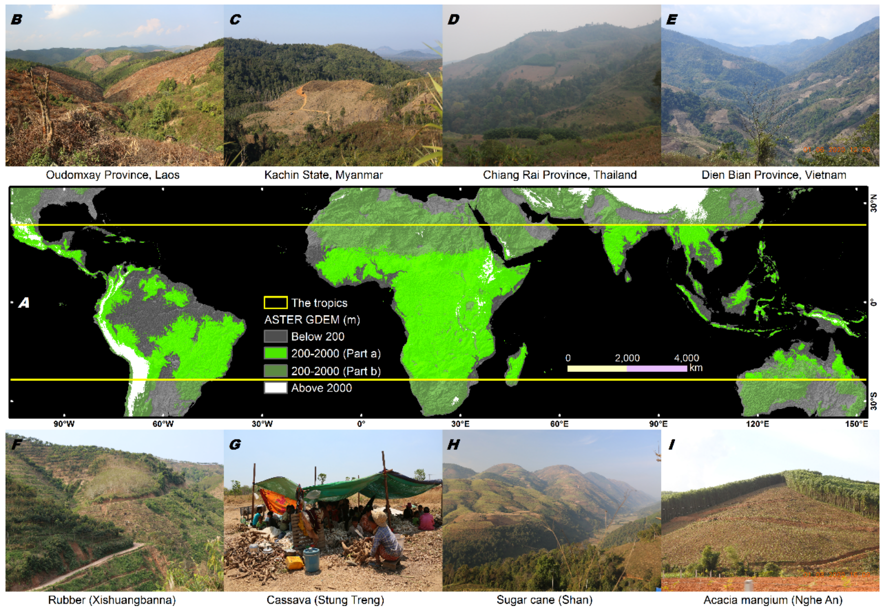
Introduction

Swidden agriculture (also called slash-and-burn or shifting cultivation) including the length of fallow period and its intensity is continuously evolving or being transformed since the mid-20th century, however, it remains a widespread but controversial farming practice and/or land use category in tropical uplands (see the figure, panel *A*)(Cairns, 2015; Heinimann et al., 2017; van Vliet et al., 2012). Sometimes, this is a straw to clutch for millions of impoverished upland ethnic groups facing constantly-changing market and extreme climates (e.g. El Niño)(Cramb et al., 2009; Smith & Dressler, 2019). The evolution and/or transformation not only matter the swidden-dependent uplanders, but also trigger endless arguments (e.g. pros and cons) of swidden agriculture towards carbon emission and biological diversity(Fox, Castella, & Ziegler, 2014). After age-long coexistence with human beings, how will the traditional farming (or practice) develop in this century(Heinimann et al., 2017)? Will it demise or persist?



Forest-swidden-plantation in the tropics . (*A*) Tropical uplands (green parts) between 200 and 2000 m above sea level are defined here as potential distribution regions of swidden agriculture (Part a). Swiddens and fallows are reclaimed from natural and secondary forests in the uplands of Mainland Southeast Asia (MSEA, *B-E*) and are being converted to industrial plantations including rubber, cassava, sugarcane and *Acacia mangium* in Xishuangbanna, China and MSEA countries (*F-I*).

Global ongoing initiatives, such as the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD Programme)(Hurtley, 2010), the Bonn Challenge(Brancalion et al., 2019) and the 2030 Sustainable Development Goals (SDGs) etc., have repeatedly emphasized the significance of forest preservation, reforestation and afforestation on one hand, and re-pushed swidden agriculture, the traditional tropical farming practice, to the forefront of a long-standing debate of climate changes on the other(Hurtley, 2010; Ziegler, Fox, & Xu, 2009). In the past decades, the alternative development of swidden agriculture is often considered as the “only way out” due to the threat to forests(Ziegler et al., 2009). This is usually the case of pioneer swiddening(Fox et al., 2000), but not for swidden agriculture as a whole(Dressler, Smith, Kull, Carmenta, & Pulhin, 2020). So far, less attention is given to its significance to local livelihoods and cultural identity of millions of marginalized shifting cultivators(Cramb et al., 2009). As swidden farming evolves or being transformed, then, how did swidden agriculture itself and the length of fallow period (or intensity) change in the past decades? What are the roles in and contribution to the gain and/or loss of natural and secondary forests by the combination of swidden-fallow? And how are swiddens (including fallows) transformed into other land use types, especially the various industrial plantations (e.g. rubber)? Last but not least, how and in what degree do global initiatives (e.g. the UN-REDD Programme) impact the tropical forest-swidden-plantation (FSP) nexus?

The uncertainties of the development of swidden agriculture and its dynamics

Many facets limit our understanding of swidden agriculture. The lack of geographic and demographic data and information on their corresponding dynamics across the tropical regions undoubtedly further aggravate the uncertainties surrounding above questions(Heinimann et al., 2017; Mertz & Padoch et al., 2009; Padoch et al., 2007). Ever since the first appeal of the eradication of shifting cultivation by the FAO in the late 1950s(FAO Staff, 1957), *in situ* anthropological, ethno-ecological and/or ethno-biological studies dominated for a long time(Brush, 1975). The launch of Landsat satellites in the 1970s offers the feasibility and marks the beginning of periodically observing this ancient farming system(Conant & Cary, 1977). However, research progress in the algorithms for mapping swiddening or shifting cultivation is not prominent, if not retarded or stagnant(Li, Feng, Jiang, Liao, & Zhang, 2014). So far, the only thematic map of global shifting cultivation, largely speculative and conspicuously old-fashioned, was firstly reported in 1980(Hurtt et al., 2011), although a few new attempts have emerged recently at regional scale, e.g. montane mainland Southeast Asia(Li, Feng, Xiao, Boudmyxay, & Liu, 2018; Li & Feng, 2016). In addition, the annually-changing and spatially-random dynamics of swidden agriculture mean that it is seldom included in existing classification maps of land cover and land use(Padoch et al., 2007), plus prevailing governmental eradication policies. The report of shifting cultivation maps in South and South East Asia, China, Africa, and South America based on the SPOT-VGT based Global Land Cover 2000 (1km) can be consider an early attempt via remote sensing at large scale(Silva, Carreiras, Rosa, & Pereira, 2011). However, the question about the accuracy of the 1km-resolution regional maps always persists as tropical swidden agriculture belongs to small-scale farming systems with small-sized plots (about 0.01km^2)(Li et al., 2014). Even worse, longitudinal dynamics of the evolution or transformation at a coarse resolution increases greater uncertainty. Unsurprisingly, few studies have been involved the spatiotemporal dynamics(Li et al., 2018). Lately, the contributions of shifting agriculture and other four factors to global deforestation were quantitatively for the first time(Curtis, Slay, Harris, Tyukavina, & Hansen, 2018). However, the fact that shifting cultivation is still practiced in many extra-tropics regions including Europe, North America, Australia, North China and many other countries is problematic and unconvincing. Since shifting cultivation is one of the main causes of tropical active fires(Cochrane, 2003; Li, Xiao, Feng, Li, & Zhang, 2020) and shifting cultivators are typically poor ethnic minorities in remote uplands with limited accessibility(Mertz & Leisz et al., 2009), the estimation of greenhouse gas emissions and achievement of the SDGs will be impacted without accurate figures and maps for the land coverage of swidden agriculture.

Shifting agriculture as well as commodity production, forestry and wildfire are the leading drivers of global forest loss(Curtis et al., 2018). Among them, the first two were preeminent in tropical regions particularly in the past two decades, which are always accompanied by frequent fire occurrence or biomass burning especially during the dry season. Anthropogenic fires not only occur in tropical upland and lowland agriculture, but also in tropical agriculture-forest frontiers (TAFF)(Li et al., 2020). In the uplands, vegetation fires are generally related to traditional practice of slash and burn(Cochrane, 2003), which acts as a key part of swidden agriculture. In the past, the words of “slash and burn” meant primitive and backward, or the stumbling block of national economic development. By the same token, the overgeneralization of describing swidden system as old as the hills could make us bet on the wrong horse(Pham Thu, Moeliono, Wong, Brockhaus, & Dung, 2020). Conversely, this becomes more necessary as increasing evidence are connected with social and ecological outcomes of this farming system(Downey, Gerkey, & Scaggs, 2020; Ziegler et al., 2012). The positive effects of swidden agriculture are gaining ample and convincing evidence in the aspects of carbon fixation, biodiversity maintenance, livelihoods risk and cultural identity(Dressler et al., 2020). Then, why should we still stick to the one-sided views of swidden systems?

The forest-swidden-plantation (FSP) nexus in the tropics

First, there is a need to carry out a synergic analysis of the tropical forest-swidden-plantation (FSP) nexus more than at any time in history under the context of rapid deforestation. The FSP nexus integrates both natural/secondary forest and commercial plantation as the anterior and posterior ends with swidden agriculture (also swiddening practice) as the main thread. This integration contributes to understand the self-evolution of swidden agriculture (including fallow period and intensity), and also is helpful to investigate its corresponding roles in natural forest changes (gain or loss) and expansion of tropical plantation(Ziegler et al., 2009), such as tree crops (e.g. rubber, coffee, and pulp trees) and non-tree crops (e.g. banana, pineapple and sugarcane). Although recent studies have enriched significantly our knowledge of forest loss(Curtis et al., 2018; Hansen et al., 2013) and plantation expansion(Peltzer, Bellingham, Dickie, & Hulme, 2015; Ziegler et al., 2009), the previous research has proceeded separately and yet to be integrated under the umbrella of sustainable development of swidden agriculture. In particular, much less is known about the processes, mechanisms, and future trends of the interplays of natural and secondary forests changes, swidden agriculture evolution and transformation, and commercialized plantations expansion in the tropics (see the figure, panel *B-I*).

Second, there is a need to integrate remote sensing methods with more traditional research. Consistent mapping of annual dynamics of swidden agriculture (including fallow cycles) and cash crops plantation facilitates tracking the advance trajectories of agricultural expansion or forest loss (retreat) in TAFF. With the free access of satellite imagery including Landsat and Sentinel-2, more efforts and new algorithms are necessary to map and investigate the dynamics of swidden-fallow trajectories, forest gain and/or loss, and plantation expansion. People often question the data availability of optical satellite imagery (e.g. Landsat) for mapping swidden agriculture and rubber plantations in the tropics especially during the growth periods, usually overlapping with the rainy season. However, this situation is totally improved within a half-year dry season due to the tropical monsoon climate(Li, Feng, & Xiao, 2018). Notably, the rotational and commonly-used slash-and-burn phases (especially the signal of fire) provide a key window for monitoring the transition from primary forest to monoculture using phenology-based methods and/or machine learning algorithms (e.g. random forest and neural network).

Finally, there is a need to understand the mechanisms through phenomena of forest change (esp. deforestation), swidden transformation, fallow period shortening, and plantation advance. Usually, the variation in drivers and/or mechanisms of the FSP dynamics are huge in different parts of the tropics. As for drivers of global deforestation, for instance, there are agro-industrial crops, plantations (including oil palm), pasture, small-scale clearing, selective logging, fire, and infrastructure/natural disturbance(Seymour & Harris, 2019). Population growth and migration, livelihoods diversity, markets and infrastructure development, public policies and attitudes and other socio-cultural drivers influence the persistence or demise of swidden agriculture(van Vliet et al., 2012). Offsetting carbon, increasing bioeconomy demand, urban migration, and government programs serve as the potential drivers of tropical plantation expansion(Rudel, 2009). Geo-economic cooperation mechanisms, national policies on land allocation, forestry, agriculture and natural resources, and local (including household level) agricultural practices are comprehensively needed to probe into the mechanisms through a bottom-up inductive approach.

Conclusions

Although swidden agriculture has long been at the center of the debates over climate change and biodiversity, it remains an essential livelihood source for hunter-gatherers and become an increasingly important farming system for global ongoing initiatives. Global rising demand of food, commodities and bio-energy by a growing population have telecoupling effects on tropical commercial plantation expansion. Meanwhile, land scarcity and loss due to dispossession and grabbing in the name of forest conservation and development diminish swiddening practices and shorten fallow cycles, which undermine the sustainability of swidden agriculture in this century. In view of the importance and research status of swidden agriculture, we proposed the framework of forest-swidden-plantation (FSP) nexus in the tropics and highlighted the processes, mechanisms, scenarios of the dynamics of the FSP nexus on one hand, and to promote the sustainable development of swidden agriculture for sake of a synergetic goal of global climate mitigation and tropical poverty alleviation on the other hand.

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